EFFECTS OF SPLIT APPLICATION OF FERTILIZER AND PLANTING DENSITY ON YIELD, COMPONENTS OF YIELD AND OTHER AGRONOMIC CHARACTERS OF RICE

by

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INTRODUCTION

Fertilization of rice in Taiwan is generally based on a well established practice of applying the total amount of phosphate, potash and half of nitrogen fertilizers as a basal dressing and the balance of nitrogen as a top-dressing at the time of second weeding. This method of fertilization usually stimulates vigorous vegetative growth of rice at the early stage of growth, especially under tropical environmental conditions which favor an early establishment of vegetative parts of rice. The growth, however, is considerably depressed at the later stage. This type of growth is considered as one of the reasons that causes lower yield in the tropical area. Furthermore, the failure of crop due to lodging and prevalence of rice blast disease may also be related in one way or another to the conventional method of fertilizer application.

Although a considerable work has been done regarding the nutrient requirements of rice, only limited data are available as to the effect of split application of fertilizers on the yield and other related characteristics. It is therefore, justified to say that more attention should be directed to the study of reasonable splitting rather than mechanical increase of fertilizers, if further increase of yield from paddy rice is to be expected. Emphasis should also be placed on the investigation of close spacings and its probable relationship with fertilization since it has been gradually becoming an important cultural practice in Taiwan.

The experiment reported here was designed to (a) determine the effects of two different methods of fertilizer application and two densities of planting on yield, components of yield and other characters, (b) determine the relationship between fertilization and density, and (c) determine the effect of fertilization and density on lodging of rice.

REVIEW OF THE LITERATURE

As early as 1939 in the wartime Japan, the effectiveness of fertilization at the ear primordia formation stage (panicle fertilization) was already recognized (Ishizuka and Tanaka, 1954). Noguchi (1949) investigated the effect of panicle fertilization

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from the physiological standpoint of rice and finally reached a conclusion that panicle fertilization was effective for the increase of panicle length, number of flowers per ear and the production of dry matter. Nagai (1959) also pointed out that split application of fertilizer during the period of ear primordia formation would greatly help the full development of panicles. Matsuo (1948) concluded that yield increase of rice by split fertilization at 20 to 30 days before heading was due primarily to (a) increase of ear-bearing tillers, (b) increase of the number of grains per ear and (c) favorable photosynthetic activities and ripening conditions which contributed to the increase of weight per 1,000 grains.

Split fertilization of fertilizer has been generally observed to be effective in nitrogen simply because it is more easily to loss either by leaching or by other means (Shirosita, 1954; Nagai, 1959). It may also be due to the fact that nitrogen is most closely related to the growth of rice than the other nutrients. Recently, however, the necessity of split application of potash fertilizer was also being stressed (Mitsui, 1954; Matsuwura, 1962). No significant difference was observed between the basal and split application of phosphate fertilizer (Matsuo, 1948).

The best time for applying split portions of nitrogen fertilizer was generally agreed to be: the first application at the time of maximum tillering stage or about 20 days after transplanting and the second application at the ear primordia formation stage or about 40 days after transplanting (Matsuwura, 1962). Yields were reduced when a split portion of nitrogen was applied later than 40 days after transplanting because of delayed maturity and increased danger of lodging (Mikkelsen and Miller, 1963). However, the nitrogen fertilization at the milk ripe stage or 80 days after transplanting was reported to be still effective for the increase of grain yield (Matsuwura, 1962).

The best splitting ratio for nitrogen fertilizer was suggested by Suzuki (1954) as 4:3:3 for basal, first top- and second top-dressings respectively, while Matsuwura (1962) obtained better results from both 2:2:6 and 2:4:4 for basal, first top- and second top-dressing respectively. The splitting ratio for potash fertilizer was, however, still unknown.

The relationship between split application and planting density was investigated by Noda (1946). He found that yield increase of split fertilization was greater in the closely spaced plots. Matsuwura (1962) observed that the length of internodes near the ground surface was considerably shortened by split fertilization which led to the reduction of lodging.

MATERIALS AND METHODS

The experiment was carried out on the second crop of 1963 at Chiayi Agricultural Experiment Station. The paddy field is of clay loam soil with pH value, organic matter and available phosphorus contents ranging from 5.3 to 5.6, 1.60 to 1.75% and 40 to 65 kg. per hectare, respectively, according to the analysis made by Taiwan Agricultural Research Institute.

The variety developed at this station, Chianung 242 was used in this experiment. It is of panicle type Japonica rice variety with large and heavy panicles. The culm of the plant is relatively tall, so it is generally susceptible to lodge. Nevertheless, it is highly resistant to rice blast disease (*Piricularia oryzae*) and is also noted for its high yielding ability.

Two treatments were included in this experiment: method of fertilization and planting density. In the method of fertilizer application, two methods were compared, i. e. conventional method of fertilizer application commonly practised by local farmers and the method of split application of fertilizers. All of P, K and half of N were used as a basal dressing and the balance of N used as a top-dressing at the time of second weeding or 20 days after transplanting in the former method while in the latter, all of P, 2/3 of K and 1/5 of N were applied as a basal dressing, 2/5 of N as first top-dressing made at the time of second weeding or 20 days after transplanting and the rest 1/3 of K and 2/5 of N used as second top-dressing at 42 days after transplanting. The total amount of fertilizers used in this experiment was 80, 40 and 40 kilograms per hectare for N, P and K respectively in both methods of fertilization.

For the planting density, there were two levels of planting density, i. e. conventional spacing with 64 hills per *Pen* (3.3 m^2) and high planting density with 96 hills per *Pen*. The distance between row was 24 cm for both densities while the distance within row was 21.5 cm and 14.3 cm for conventional and high planting densities respectively.

Each plot was 10 m^2 in area which is equal to 1/1,000 hectare. The experiment was laid out in split-plot design with methods of fertilizer application as the main treatments and the planting densities as sub-treatments. The experiment was replicted four times. It was transplanted on August 1, 1963 and was harvested on November 14, 1963.

Plant height and number of tillers per hill were recorded at 40 days after transplanting, while the number of panicles per hill and plant height were again measured at the full ripe stage. Heading date was recorded as the number of days from transplanting to about half of ear-bearing tillers being completely headed. The length of internodes, number of grains per ear, average weight of panicle, average length of panicles and weight of 1,000 grains were measured for each plot based on 20 randomly sampled plants, one from each hill. The percentage of lodging was recorded on the day before harvesting, and the grain yield was based on the total grain yield of each plot.

All data collected were subjected to the analysis of variance. In the percentage of lodging, arcsin transformation was made before conducting analysis, according to the method shown by Snedecor (1961).

EXPERIMENTAL RESULTS

Effects of Fertilizer Application and Planting Density on Yield and Components of Yield.

The average yield, components of yield and F values from the analysis of

variance are given in table 1.

Table 1. Grain yield, components of yield and their F values of rice variety Chianung 242 under different methods of fertilization and planting densities

Method of fertilization	Planting density (hills/Pen)	Grain yield (kg/ha)	Number of panicles per hill	Number of grains per ear	Weight of 1,000 grains (g)
Conventional	64	4,311.75	9.78	152.11	27.88
	96	4,515.75	7.88	144.98	28.06
Splitting	64	4,565.75	9.35	158.65	29.00
	96	4,866.75	7.23	146.51	29.31
Average for conventional	—	4,413.75	8.83	148.55	27.97
Average for splitting	—	4,711.75	8.29	152.58	29.16
F values	—	8.29	7.25	7.08	63.19**
LSD 1%	—	—	—	—	0.81
Average for 64 hills	—	4,434.25	9.57	155.38	28.44
Average for 96 hills	—	4,691.25	7.56	145.75	28.69
F values	—	12.16*	62.31**	2.35	0.29
LSD 5%	—	180.39	0.62	—	—
Fertilization X Planting density					
F values	—	0.52	0.19	0.16	0.01

* Difference significant at the 5% level.
** Difference significant at the 1% level.

Grain yield was 298 kg or 6.75% higher per hectare in split application of fertilizer than that of conventional one, a difference that just failed to reach a level of significance. High planting density of 96 hills per *Pen* (3.3 m^2) produced 257 kg or 5.79% more grain per hectare than that of 64 hills pre *Pen*, a planting density most commonly adopted by local farmers. This difference between planting densities exceeded the 5% level of significance.

Grains from split use of fertilizer were heavier than those from conventional one, averaging 1.19 gram or 4.25% heavier per 1,000 grains. This difference was significant at 1% level of probability. Grain weight was not affected by planting densities.

Methods of fertilization did not cause a significant change in the number or panicles per hill, even though it showed a slight increase in conventional fertilization. However, high planting density reduced nearly 2 panicles per hill, a difference greatly exceeding the 1% level of probability.

The number of grains per ear appeared to be unaffected by both treatments. Nevertheless, there was an indication for split fertilization to have slightly more grains per ear and for high planting density to produce less grains.

No significant interaction between fertilization and planting density was evident in grain yield and components of yield.

Effects of Fertilizer Application and Planting Density on some Agronomic Characters.

Agronomic characters measured in this study included heading date, plant height, number of tillers, panicle weight and panicle length. A summary of the data and F values conputed on these characters are presented in table 2.

Table 2. Means and F values of heading date, plant height, number of tillers, panicle weight and panicle length of rice variety Chianung 242 subjected to the treatments of fertilization and planting density

Method of fertilization	Planting density (hills/Pen)	Heading date (days)	Plant height		Number of tillers per hill	Panicle weight (g)	Panicle length (cm)
			40 days (cm)	Full ripe (cm)			
Conventional	64	60.5	88.8	109.2	9.0	4.3	23.06
	96	60.5	91.5	108.2	7.2	4.0	23.03
Splitting	64	59.0	85.8	111.9	8.4	4.6	24.73
	96	59.8	82.6	109.6	7.5	4.1	24.23
Average for cenventional	—	60.5	90.2	108.7	8.1	4.2	23.05
Average for conventional	—	59.4	84.2	110.8	8.0	4.4	24.48
F values	—	1.36	3.87	4.09	0.36	16.0*	274.72**
LSD 5%	—	—	—	—	—	0.16	0.28
Average for 64 hills	—	59.8	87.3	110.6	8.7	4.5	23.90
Average for 64 hills	—	60.2	87.1	108.9	7.3	4.1	23.63
F values	—	0.78	0.03	0.69	14.02**	4.33	0.84
LSD 1%	—	—	—	—	1.40	—	—
Fertilization X Planting F values	—	0.75	3.40	0.10	1.40	0.07	0.62

* Difference significant at the 5% level.
** Difference significant at the 1% level.

From table 2, heading date was found to be one day earlier in split fertilization than that of conventional one, but it remained almost the same in both planting densities. Planting height in split fertilization averaged 6 cm lower and 2 cm taller than that of conventional one at 40 days after transplanting and at full ripe stage respectively; while plant height of high planting density appeared to be consistently lower than that of low planting density at both stages. Differences in two characters, however, were not significant for both treatments.

The number of tillers was not affected by methods of fertilization, but it reduced 1.3 tiller per hill in high planting density, a difference greatly exceeding the 1% level of probability.

Panicles from split fertilization were significantly heavier than those from conventional one, but panicle weight was not significantly affected by planting densities. The length of panicles was 1.43 cm or 6.16% longer in split fertilization than that of conventional one. This difference was highly significant. Planting densities did not cause a significant change in panicle length.

In all characters analyzed, the interaction between fertilization and planting density appeared to be not significant.

Effects of Fertilizer Application and Planting Density on the Length of Internodes and Lodging.

The average length of internodes, the percentage of lodging and F values obtained from the analysis of variance for these two characters are summarized in table 3.

Table 3. Means and F values of the length of internodes and the percentage of lodging of rice variety Chianung 242 under different methods of fertilization and planting densities

Method of fertilization	Planting density (hills/Pen)	Length of internodes (cm)					Lodging (%)
		1st.	2nd.	3rd.	4th.	5th.	
Conventional	64	41.47	21.86	14.10	8.02	3.73	43.2
	96	42.46	22.35	12.77	8.05	2.49	46.3
Splitting	64	45.56	21.56	11.51	7.97	1.58	3.7
	96	45.58	21.51	10.84	7.49	2.11	15.7
Average for conventional	—	41.97	22.11	13.44	8.04	3.11	44.8
Average for splitting	—	45.57	21.63	11.18	7.73	1.85	8.7
F values	—	108.2**	2.12	17.24*	2.00	6.74	14.48*
LSD 5%	—	1.10	—	1.73	—	—	20.7
Average for 64 hills	—	43.52	21.80	12.81	8.00	2.66	19.4
Average for 96 hills	—	44.02	21.93	11.81	7.77	2.30	29.9
F values	—	0.33	0.20	9.96*	0.38	3.30	0.96
LSD 5%	—	—	—	0.77	—	—	—
Fertilization X Planting density F values	—	0.31	1.63	1.06	0.48	20.33**	0.53

* Difference significant at the 5% level.
** Difference significant at the 1% level.

The plant in split fertilization was found to have longer first internode but the rest of internodes were all shorter than those of conventional one. Differences in the first and third internodes exceeded the 1% and 5% levels of probability respectively; while those in the rest of internodes were not significant. Planting densities did not cause significant changes in all internodes except in the third internode where the difference between planting densities was significant at the 5% level of probability.

The percentage of lodging was lower in split fertilization than that of conventional one, the mean percentages of lodging being 8.7% and 44.8% respectively. This difference exceeded 5% level of significance. Planting densities did not significantly affect the percentage of lodging, even though there was a tendency for high planting density to have higher percentage of lodging.

The interaction between methods of fertilization and planting densities was not significant in the upper four internodes, but it was highly significant in the fifth internode. No significant interaction between the treatments was observed

in the percentage of lodging.

DISCUSSION AND CONCLUSIONS

It was observed in this experiment that split application of fertilizers produced higher grain yield than did conventional one, indicating that by merely adjusting the fertilizer usage could lead to the increase of yield. The results obtained were similar to those reported by other workers (Suzuki, 1958; Matsuwura, 1962). However, the difference in yield somehow failed to reach level of significance. This may be due largely to the allocation of fertilizer application to the main plots, thus reducing the efficiency of comparison in the main treatments.

The analysis of components of yield revealed that the number of panicles per hill and the number of grain per ear were not affected by methods of fertilization, but the weight of 1,000 grains was significantly increased by split application of fertilizers. It is probable, therefore, that yield increase caused by split fertilization may be attributable to the increase of grain weight.

The fact that fertilization at the ear primordia formation stage leads to the increase of the weight of grains and thus to the increase of yield, has been proved by many workers (Matsuo, 1948; Snzuki, 1958; Nagai, 1959). The fertilization at this stage seems to have twofold effects: one is to help make larger size of hulls and the other, to provide favorable conditions for the full development of the maturing grains. Nagai (1959) reported that the weight of mature grains is greatly influenced by the size of hulls which hold the ripening grains. The size of hulls can be modified to certain extent by the favorable growth condition during the ear primordia formation stage. If the container of the grain be made large, the development of the grain may proceed to the utmost size. Noguchi (1949) concluded that fertilization at ear primordia formation stage did increase the rate of CO_2 uptake and stimulate the activities of photosynthesis, thus contributed to the high dry matter content of the grain as well as producing a plump and heavy grain. It is well understood that the activities of photosynthesis are vital importance to the yield, since the grain yield depends on the products of photosynthesis stored in the grain in the form of starch.

The time of applying second top-dressing or so-called panicle fertilization seems to have played an important role on components of yield. Matsuo (1948) reported that fertilization at 20 to 30 days before heading resulted in the increase of ear-bearing tillers, number of grains per ear and weight of 1,000 grains. When fertilized at 10 to 15 days before heading, the latter two components would increase, but only the weight of 1,000 grains was increased if fertilized after 10 days before heading. His observation was found to be quite similar to the results obtained in this experiment. The second top-dressing was made at 42 days after transplanting or 16 days before heading in this experiment and it appeared to be a little late for the increase of panicles. This was reflected in the slight reduction of panicles in the treatment of split fertilization. The number of grains was slightly increased

but the effect of second top-dressing seemed to be centered on the increase of grain weight. The reduction of panicles did not affect the yield since it was reported that the relationship between the two was not necessarily parallel (Matsuwura, 1962). Matsuo (1948) and Suzuki (1958) also suggested that the number of panicles per hill and the number of grains per ear are merely the constructing components of yield which presumably contribute only to the potentiality of yield while the weight of 1,000 grains is the real decisive component of yield which determines the actual yield.

Grain yield was significantly increased by high planting density, indicating that close spacing was effective for the increase of yield. Since the components of yield were adversely affected by high planting density except the weight of 1,000 grains which remained unchanged, it would appear, therefore, that the yield increase in high planting density was contributed entirely by the increase of panicles per unit area. The total number of panicles per plot was calculated as 1,854 in conventional rate of planting while that of close spacing was 2,200, an increase of 346 panicles or 18.69%. This increase of panicles not only compensated for the reduction of the number of panicles per hill and the number of grains per ear but also contributed to the increase of yield. The same results were also reported by other workers. Mizukami (1962) observed the existence of a high correlation between the number of panicles per unit area and the grain yield in rice. Wilson and Swanson (1962) also found that a reduction in heads per square foot led to a significant reduction of grain yield in winter wheat.

It was indicated that a plot treated with split application of fertilizers and high planting density produced more yield, even though no significant interaction occurred between the treatments. The same result was also reported by Noda (1946). He concluded that the percentage of yield increase caused by split application of fertilizers was greater in the plots of high planting density. In view of a current trend prevailing in Taiwan to raise degree of planting density, the result obtained in this experiment seems to have a practical value, since it has pointed out a possibility of further yield increase by applying split fertilization in the closely spaced field.

Heading date was found to be one day earlier in split fertilization. Field observation made during the period of ripening stage clearly indicating that plants in the plots of split fertilization were far ahead in maturing. The early maturity of the plants in the plots of split fertilization may be caused by the application of potash fertilizer at second top-dressing. As observed by Mitsui (1954), potash fertilization at ear primordia formation stage was considered to be associated with the development of young panicles and to provide favorable conditions for the ripening of grains.

The effect of split application of fertilizer was probably best reflected in plant height. Under conventional method of fertilization, the growth of plants was generally vigorous at the early stage presumably due to sufficient amount of fertili-

zers available in the soil, but at the later stage, the growth was ocnsiderably depressed probably caused by the exhaustion of nutrients. This was clearly indicated by plant height, i. e. taller plants in the former and shorter ones in the latter. Furthermore, the prevailing climatic conditions in tropical area were reported to have a tendency to stimaulate the overgrowth of vegetative parts of rice (Suzuki, 1958). As a result, the occurrence of lodging as well as the prevalence of blast disease of rice may become more serious and this is actually the case in Taiwan. Split application of fertilizers seems to offer a probable solution to these problems. As revealed by the data, rice plants were well under control at the early stage of growth as indicated by shorter plant height in the plots of split fertilization, and they also maintained a better growth at the later stage.

The increase of panicle length in the plots of split application of fertilizer was found to be closely associated with panicle weight. A high correlation coefficient of +0.64 was obtained by Iso (1934) between these two characters. Noguchi (1949) also reported that the increase of panicle length was one of the significant responses of rice plants to the so-called panicle fertilization. It is believed that the increase of panicle length and panicle weight may be related to the increase of grain weight and thus, to grain yield.

A highly significant reduction in the number of tillers per hill presumably led to the highly significant reduction of the number of panicles per hill in the high planting density. It is suspected that the reduction of tillers as well as panicles per hill may be due largely to the keen competition for space and nutrients brought about by the increase of population density. Panicle weight and panicle length were also found to be reduced in high planting density. Wilson and Swanson (1962) also reported that heads generally decreased in weight and length as the population increased.

The length of the first internode in the plots of split fertilization averaged 3.6 cm longer than that of conventional one. Hosika (1961) reported that the length of the first internode was associated with the yielding ability of rice plant, the longer the first internode, the higher the yield. It seems reasonable to suppose that yield increase due to split application of fertilizers was made possible by the high yielding type of rice plant resulted from this fertilization.

Plants in the plots of split fertilization were generally found to have shorter internodes at lower part of the culm, and they also appeared to have low percentage of lodging, indicating that shorter basal internodes of rice plants may be related to lodging. This relationship was particularly conspicuous in the fifth internode. A similar observation was also made by other investigators. Hosika (1961) reported that longer fifth internode used to increase the danger of lodging. Matsuwura (1962) quoted Yamamoto as saying that lodging scarcely occurred when length of the fifth internode was shorter than 2.5 cm. Investigations made by Kaohsiung Agricultural Experiment Station (1963) revealed a tendency for a light unit weight of the third internode of rice plants to associate with a high percentage

of lodging. A significant difference in length of the third internode between methods of fertilization seemed to indicate that the length, in addition to unit weight, of the third internode was also related to lodging. However, the relationship between length and lodging was not clear in closely spaced plots, suggesting that other factors were also involved in the mechanism of lodging.

Lodging of two spacings responded similarly but in different degree to split fertilization. In wide spacing, the reduction of lodging due to split fertilization was larger than that of close spacing. Since the fifth internode was suggested to be related to lodging, a highly significant interaction occurred in this character seemed to indicate that a certain degree of interaction might also exist in lodging between the two treatments. Based on this observation, it appears promising that split fertilization may be an useful tool for an effective control of lodging.

In this experiment, splitting of fertilizer was made for N and K, but not for P. This was based on the fact frequently demonstrated by experiment and practical experience that yield response of phosphoric fertilizer is less significant in paddy soils. Nagai (1959) reported that nearly 70 percent of the phosphoric acid applied in paddy field could be retained in the soil as readily available ferrous phosphate and only 0.8 percent of it was lost through leaching, suggesting that splitting use of phosphoric fertilizer may be unnecessary. Mitsui (1954) also concluded that sufficient amount of phosphoric fertilizer applied as a basal dressing would be enough to cover the need for a maximum yield. Further investigations on this and other problems seem necessary.

SUMMARY

A panicle-type Japonica variety of rice Chianung 242 was subjected to two methods of fertilizer application namely, conventional and split methods, and two levels of planting density, 64 hills and 96 hills per *Pen* (3.3 m^2). The experiment was arranged in split plot design with methods of fertilization as main treatments and planting densities as sub-treatments. The experiment was replicated 4 times on the Experimental field of Chaiyi Agricultural Experiment Station in the second crop of 1963. Data on grain yield, components of yield and other agronomic characters were taken to determine the effect of both treatments as well as their interactions.

Split application of fertilizer was found to produce higher yield than conventional method of fertilization. The yield increase was found to be due largely to the increase of grain weight. The increase of grain yield by high planting density was also significant and it was attributable to the increase of panicles per unit area.

The weight and length of panicles were significantly increased by split application of fertilizers, but they were generally decreased as the plant population increased. Heading date and plant height were not significantly affected by both treatments.

The first internode was significantly longer in the plant of split fertilization but the rest of the internodes were shorter than those of conventional one. A similar trend of smaller magnitude was also observed in planting density. The long first internode of rice plant was found to be related to high grain yield.

Lodging was significantly reduced by split fertilization but no significant difference occurred in planting densities. The relationship between the length of internodes and the percentage of lodging was still not clearly understood.

A tendency for the plot of high planting density to produce higher yield under split application of fertilizer was revealed, although no significant interaction between the treatments was evident. A similar observation was also made in the percentage of lodging, indicating a possible reduction of lodging in the plots of high planting density by the use of split fertilization.

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水稻肥料分施與栽植密度對產量，產量構成因子及其他主要農藝性狀之效果

張萬來　楊遜謙

摘　要

本試驗分肥料施用法與栽植密度兩處理。肥料施用法爲：肥料分施（基肥：N$\frac{1}{5}$，P 全量，K$\frac{2}{3}$，全層施肥，第一次追肥：N$\frac{2}{5}$ 於第二次除草時施用，第二次追肥或穗肥，N$\frac{2}{5}$，K$\frac{1}{3}$ 於插秧後42日施用）與慣行施肥法（基肥 N$\frac{1}{2}$，PK 全量，全層施肥，第一次追肥，N$\frac{1}{2}$於第二次除草時施用）兩種。栽植密度亦分兩級，卽：密植或每坪96株與疏植或慣行栽植密度，每坪64株。本試驗於民國52年第2期作在嘉義農業試驗分所舉行，以明瞭各處理對水稻產量及主要農藝性狀之効果。茲將所得結果摘要如下：

肥料分施可增加每公頃乾淨谷產量百分之六・七五，經產量構成因子分析結果指出其增產原因爲谷千粒重之增加所致。增加栽植密度，增產百分之五・七九，差異顯著其產量之提高，乃得自單位面積內總穗數之增加。

每株分蘗及穗數不因肥料施用法而大幅增減，惟可隨栽植密度之增加而顯著減少。每穗粒數雖可因肥料分施而稍增，隨密植而稍減，但差異均不顯著，穗長與穗重因肥料之分施而顯著增加，惟因栽植密度之提高而減低，株高及生育日數，處理間差異均不顯著。

肥料分施增加稻莖第一節間長度，餘外節間頗顯縮短，而形成所謂多產型稻株。此結果經發現與產量之增加及倒伏之減少有關。惟倒伏性與稻莖節間長度之關係尙欠明瞭。

肥料施用法與栽植密度之間，雖未見顯著之交感作用存在，但肥料分施與密植之配合，每有增產之趨勢，而倒伏性亦有遞減現象。